

ART. III.—*Irrigation and Water Supply in the
Australian Colonies.*

By NEWTON E. JENNINGS, M. Inst. C.E., F.R.I.B.A.

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The want of water in many parts of these Colonies for irrigation, as well as for the working of mines, the supply of stock, and domestic purposes is generally acknowledged, it is consequently unnecessary to use any arguments to prove this

The rainfall, so far as the records show, at least in Victoria, is enough to provide a sufficient supply for all purposes if properly distributed; but being intermittent, and the supply from the various creeks, channels and rivers being variable, it cannot be relied on without the aid of some artificial means. Various plans have been proposed, such as the construction of dams or anicuts in rivers or streams to raise the water to channels for distribution; the supply of these channels by pumping and sinking wells. In the first case, the dams interfere with navigation, and in most natural watercourses the level of water varies so much, that in order to take off water at the driest seasons, the bed of the channel must be so low that the water level in it, for a considerable distance, will be below the level of the country, and a great deal of the water must be lifted, or else what is frequently the best and most profitable land, viz., that near the river, is left without irrigation, and any expenditure on lifting water where it can be avoided diminishes the profits of the cultivator, and thus renders the land less capable of bearing the cost of works necessary to bring it under irrigation, besides also employing labour which could be profitably utilised elsewhere. Water taken off from the natural channels while in flood also contains a very large quantity of silt, and as the rapidity of the flow is retarded in the channels, both because a very rapid flow would injure the banks, and because the inclination of the bed of the canal is reduced as low as possible in order to keep the level of the water above the level of the country as far as possible, the silt is deposited in the channels, thus causing considerable expense for clearing them. There is always also a tendency

for the head sluices to silt up. The cost of raising water by steam power is very great, necessitating a large initial outlay and a constant fixed expenditure for maintenance, which bears a large proportion to the profit of irrigation, and in case of partial failure of the crops, absorbs probably the whole. The use of windmills for pumping no doubt minimises the cost, but there is an element of uncertainty in their use which it is desirable to eliminate as far as possible, and consequently the supply of water should, wherever practicable, be by gravitation. The supply of water from wells occasions great cost in lifting, as a rule, and the supply is small in comparison to the quantity required, and is seldom profitable except for garden crops, or particularly remunerative ones, such as chilies in India.

The direction therefore to which irrigation schemes should turn, is the regulation of the supply of water by storing it before it reaches the rivers and watercourses, thus reducing the risk of floods, and providing against deficiency in times of drought. The distribution of water so stored is a matter for subsequent consideration. In India, the periods of drought are ordinarily about six months. Here, they are usually about the same number of weeks; the proportion of area to storage required here is consequently much less. If storage is provided for the whole of the area under command, the construction of channels for distribution may to a great extent be postponed, as in most cases only a small proportion of the irrigable land is under cultivation; and, although distribution through the natural channels is in most cases wasteful, this waste might at first be disregarded, and the channels could be constructed as more land comes under cultivation and the necessity for economy arises, while the increased area cultivated would enable the necessary funds for the work to be provided. It would very frequently be found also, that the first cost of storing the water, and thus securing a thoroughly satisfactory system of irrigation would be less, and it would very seldom exceed that of constructing weirs or anicuts on rivers of any size. It does not follow that weirs or anicuts are never desirable, but there is little doubt that in most cases storage is preferable, and that endeavours should be made to adopt this system wherever practicable.

The first steps to be taken are, to note the various catchment basins, and to establish rain gauges in suitable places. Considerable care and judgment is requisite in

selecting these situations, and experience in irrigation works is almost indispensable, so that when sites for reservoirs are selected, it may be possible to ascertain correctly the amount of rainfall which will be intercepted by the reservoir. The gauges should be of one pattern, and a uniform system of observation should be adopted in every case. Care should be taken to note the largest rainfall in limited periods, from one hour upwards, as this is of the greatest consequence to enable proper provision to be made for the discharge of the surplus water when the reservoir becomes full, as any deficiency in this respect is the principal source of danger to a reservoir. Notice should likewise be taken of the longest periods of drought and rainfall, and the minimum and maximum rainfall for extended and continuous periods, so that the capacity of the reservoir may be determined—the object being to store sufficient water for any period of drought, together with sufficient to keep up a full supply before or after the drought, during any time that the rainfall alone is insufficient for the requirements.

The next thing to be observed is the determination of the amount of run off corresponding to any particular rainfall in any district. This depends upon the nature of the soil, the slope of the country, the ratio of rainfall to the time in which it falls, whether the land is under cultivation or not, whether it is bare or wooded, and other local peculiarities. Attempts have been made to reduce these to formulæ in particular instances, but so far no one has succeeded in finding any formulæ or constants which would be applicable to different conditions. It is a subject upon which very little is accurately known, and although the gauging of rivers and streams would, to a great extent, solve the question, the ordinary systems of ascertaining the velocity and discharge give results that are by no means reliable. To give one instance, a river was gauged in the ordinary way with floats, and at the same time a series of observations were taken for every 10 ft. in breadth and every 2 ft. in depth, by means of an electric current meter, and the results of the two series of experiments differed by more than 25 per cent. The same sections of the river were used in each case, so that one element of uncertainty was wanting. Probably the latter was about as correct a result as could be obtained for a large river where it was impossible to take the actual quantity of water that had passed in a certain time, and measure it; but there is always some

amount of error in the section of a river taken in a strong current, and with probably a varying level of water. Whether any correct proportion can be arrived at between observations taken in this way, and those taken with floats in the ordinary manner, remains to be seen; but as really reliable results cannot be obtained without a very large number of scientifically conducted experiments, it will probably be a long time before any very great progress is made in the gauging of rivers and streams, and as the cost of observations taken in the way above named is very considerably greater than those taken in the ordinary manner, it is to be feared that this method will not be very generally practised. It would be very desirable if some arrangement could be made by which the various scientific bodies, engineers, and governments would communicate to each other any observations that were made by them, and the results that each deduced from them. Meanwhile the ordinary observations should be made systematically, and by the very best operators obtainable, but even then it will be necessary to be guided a good deal by the opinions of those who from experience are able to estimate approximately the amount of run off in proportion to the rainfall in different districts and under different conditions.

The next thing is to select the sites for reservoirs in connection with the land to be irrigated. For this purpose men of special experience are required, as they must be able to choose sites favourable for the construction of reservoirs, judge approximately whether the rainfall over the catchment area would be sufficient to fill it, whether if filled it would provide for the irrigation of all the land under its command, and to do this they must be able to judge what land would be irrigable from it. The site for a reservoir should be selected to command an area proportioned to its capacity, and the probable length of drought must also be taken into consideration. The depth of the water should be great, so as to reduce the proportion of loss by evaporation. The dam or bund to impound the water should be as short as possible, to save expense. The foundation must be carefully examined to see that it is suitable, and can be made water-tight. Notice must also be taken of what material is available for its construction, so as to determine whether it would be most advantageously constructed of earth or masonry. There must be a satisfactory site for

a weir or overflow, of such a length as would be necessary to carry off the maximum rainfall, and at a suitable level. It is also necessary to see that a suitable channel to carry off the overflow, either exists, or can be constructed. Note must also be made of the land which is likely to be submerged, as in many cases this is an important factor in the practicability of the scheme. It must also be seen how the head works are to be constructed, and what provision can be made for the distribution of the water; and also what facilities, or otherwise, there are for the provision of a complete system of irrigation channels. In addition to all these items, it is necessary to consider whether the quantity of land under command is sufficient to compensate for the construction of the reservoir and channels, and whether the land immediately irrigable would give a return for the cost of the reservoir, and if not, whether the prospects of additional land coming under irrigation are sufficient to compensate for any present deficiency, and the cost of preparing land not previously irrigated for the reception of water must not be lost sight of; and in estimating the probable cost of the work, the accessibility of the site, or otherwise, the means of obtaining the supplies, and method of housing the men employed, must be taken into consideration.

Having determined that on all the foregoing points there is a balance in favour of the scheme, the surveys can be proceeded with. These will commence with contours at every 10 feet in height, so as to make sure whether the anticipations are so far correct as to render it worth while to proceed. This will be a very small expense, and if found satisfactory, the survey would be continued, and intermediate contours to ascertain the exact contents of the reservoir must be taken. For this purpose, contours every 5 feet will ordinarily be sufficient to prove indisputably that the storage capacity is sufficient for the area under command, and that the rainfall will suffice to fill it up to the height proposed for the weir, and to keep up the requisite supply. In case there has not been a fairly accurate survey of the drainage area, it may be necessary to survey this also; but in cases where there is no doubt that the area is more than sufficient, or the rainfall is so heavy as to make certain of a sufficient supply, this may be postponed, unless the site for the weir is restricted in length, in which case it should be done at once, in order to

see that sufficient waterway can be provided for the surplus water.

After dealing with many other important considerations, Mr. Jennings said, with regard to the materials for construction, it will generally be found that if earth is obtainable which is not of too porous a nature, the cost will be less than stone, even if this is available on the spot. The supply of water during construction must also be taken into consideration, as the most satisfactory way of constructing an earthen dam is to water it and roll it in layers of about 6 inches thick, this forms a stronger and more impervious dam than one with only a puddle wall in the centre. It is desirable, if possible, to face the side slope next the water with stone, and consequently it will have to be noted how near the site this can be procured. Stone or brick will be required for the head works, and in most cases for the weir, and the facilities for procuring brick earth must also be investigated, as well as the question of fuel for making bricks. Sometimes a site, which to an unexperienced eye appears most unpromising, turns out particularly desirable; for instance, it may be possible to construct a tunnel which will bring land under command which at first seems inaccessible, or a weir may be constructed by cutting through rock which would be supposed to be too costly, until it is remembered that the stone excavated will be wanted for the head works and for facing the dam. A low spur may run out from a range of hills, and it might appear as if the length of the dam would be excessive, but on investigation it may be found that this spur is just about the height of the dam proposed to be erected. But the discrimination of all these points can only be acquired by practise, united with natural capacity, and no theoretical knowledge will enable a man to select a site.

To sum up, therefore, what is necessary to be done in order to carry out irrigation, and thus raise the value of land many-fold, it would appear desirable that Government should take in hand the storage of water, so as to avoid any jealousies and conflict of interests. The storage should be on high ground, and well up the rivers or streams, as there can be no question as to the right of Government to intercept the rainfall of its own land, and numberless disputes may arise as to the proportion which may be intercepted or taken from a river. All works of this description should be arranged so as to be reproductive

either immediately, or in the near future, and to make them so, either a charge for water should be made according to the quantity used, or the area irrigated, or else a charge on all land under command which could obtain water if the owners or occupiers wished to take it. Whether there should be different rates for pasture and cultivated lands need not just now be discussed. Investigations as to rainfall and discharge of rivers, &c., should be systematically and energetically proceeded with, bearing in mind, that the longer the period during which such observations are made, the more correct will be the results, and they should not therefore be postponed, until any particular work is about to be executed. The country should be examined by thoroughly experienced irrigation engineers, who should select sites which appear appropriate for the construction of reservoirs, and which command land which is, or is likely to come under cultivation. Some preliminary survey of these sites would be desirable, though not essential, as, if irrigation works are required in any particular district, and funds are available, it would be preferable that these should be completely surveyed, and designs and estimates made, and when time permits, or funds are available, preliminary surveys of the rest can be carried out. If experienced men and money are still available, detailed surveys should be made, so that Government may have in their possession complete irrigation schemes for every part of the Colony, and they would be able to proceed at once whenever the necessity arose in any particular district.

Although irrigation only is mentioned in the above remarks, they are intended to apply to the conservation of water wherever required for other purposes, the only modification being as to the command of land. The questions of the distribution of water and construction of the channels for the purpose, and the discussion of the manner in which the revenue should be raised to make the works reproductive, may be left for remark on a future occasion.
